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SERVICE PARAMETERS OF ENAMELS FOR PIPES

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The service parameters of protective coatings for pipes are analyzed. It is demonstrated that the most promising and durable are glass-enamel coatings. The results of measuring microhardness and impact strength of enamels are provided. Enamel compositions are recommended to protect the surface of steel pipes from corrosion.

About 2 million km exterior pipelines and about 15 million km interior water supply, sewage, and heating pipelines are currently operated in Russia. Steel pipes are prone to intense corrosion, which amounts to 0.05 mm per year in water supply systems. The intense economic activity of large urban facilities and industrial companies causes formation of physical fields (vibration, stray current, temperature fields, etc.) that accelerate 10–15 times the destruction of steel pipes, in most dangerous zones reaching 0.9 mm per year.

To a large extent the consequences of corrosion can be avoided by applying a protective coating to the internal surfaces of metal pipes that transport not only water but aggressive industrial liquids as well. For this purpose, plastic, epoxy, paint-and-varnish, metal, sand-ceramic, and glass-enamel coatings are deposited on pipe surfaces. The main technical characteristics of some types of coatings are listed in Table 1.

The most effective and promising are silicate-enamel coating. The grade of enamel is selected depending on media transported via the pipes, their content of acids, alkalis, salts, and mechanical impurities. The coating thickness is 300–500 μm , and the service temperature interval ranges from 150°C below zero to 400°C above zero.

Enamelled pipes in service experience the effect of the aqueous medium, abrasive loads, and impact and temperature loads; consequently, we investigated the chemical resistance, impact strength, and microhardness of coatings which characterized the wear resistance of enamel coating.

The water resistance of enamels was determined by the surface method in distilled water (GOST 24788–81). It can be seen in Table 2 that the highest water resistance is observed in enamels of the first series; however, the enamels of the second series are only slightly inferior. This is due to a lower content of SiO_2 in the enamels of series 2 compared to series 1 and their higher content of metal oxides.

The impact strength tests were conducted according to the method specified in GOST 24788–81 standard. We investigated borosilicate alkali-bearing enamels in which the amount of iron and manganese oxides varied from 12 to nearly 30%. Impact strength is one of the most important parameters of coatings, since pipes in service experience substantial impact loads. The measurement of the microhardness (PMT-3 microhardness meter) of each sample was repeated 10 times, after which average values were taken. The testing results are listed in Table 2.

TABLE 1

Parameter	Protective coating		
	low-density polyethylene	epoxy resin (solidified)	silicate enamel
Density, g/cm ³	0.92–0.93	1.36–1.39	2.30–2.60
Strength, MPa:			
tensile	12.0–16.0	70.0–80.0	40.0–90.0
compressive	12.5–14.5	110.0–160.0	80.0–180.0
Brinell hardness, MPa	4.3–5.2	1.0–1.2	40.0–80.0
Water absorption in 24 h, %	0.01	0.30	Totally impermeable
Service temperature limit, °C	80–100	100–110	300–500

TABLE 2

Enamel	Water resistance, mg/cm ²	Weight content of iron and manganese oxides, %	Impact strength, J	Microhardness, kg/mm ²
1	4.5	12.0	1.82	557
1.1	0.3	14.0	5.00	665
1.2	0.2	14.3	5.70	680
2.1	1.2	20.7	6.80	680
2.2	1.4	25.2	7.90	685
2.3	0.6	29.6	7.30	715

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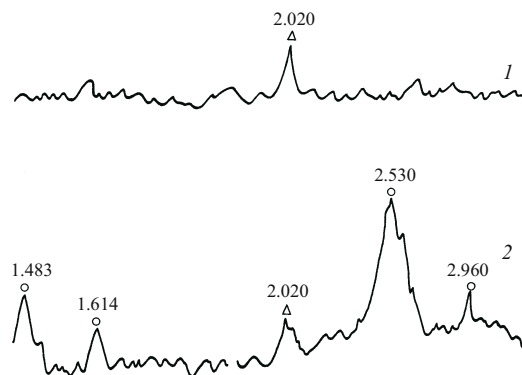


Fig. 1. Diffraction patterns of enamels from the first (1) and second (2) series heat-treated at 760–780°C: Δ) borate; \circ) magnetite.

The enamels of series 2 have higher impact strength than those of the first series, especially enamel 1. It is known [1] that the impact strength of an enamel coating depends on the degree of its crystallization and the adhesion of enamel to metal. Fractures under a strong impact in all the enamels considered occur not along the metal-enamel interface, but

inside the enamel layer. This proves that all enamels have sufficiently good adhesion to metal and their impact strength depends only on the degree of crystallization of the coating.

It can be seen from the data in Fig. 1 that the diffraction pattern of the enamel from the first series has only one peak typical of borate, whereas the diffraction pattern of series 2 enamel, apart from the specified peak, has peaks typical of magnetite as well. Considering that the crystalline phase in enamel 1 is absent and there are no peaks typical of the enamels of the first and the second series, it can be stated that an increase in microhardness is due to the crystallization of enamel. The obtained data indicate that the degree of crystallization in enamels with a high content of iron and manganese oxides is higher, which is corroborated by their higher values of microhardness and impact strength.

Enamels 1.2 and 2.1, which have better service properties, can be recommended for application as silicate-enamel coatings.

REFERENCES

1. *Technology of Enamels and Protective Coatings. Manual* [in Russian], Novocherkassk, Kharkov (2003).